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Effects of Clearcutting a Subalpine Forest in Central Colorado on Wildlife Habitat

Glenn L. Crouch

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Effects of Clearcutting a Subalpine Forest in Central Colorado on Wildlife Habitat

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Abstract

Clearcutting 3-acre circular blocks on average and moist sites increased understory plant production and cover, but caused few changes in species composition. Plant moisture and crude protein content, and digestibility also increased after logging; but, incidence of herbivore activity varied among species.

[1]*Headquarters is in Fort Collins, in cooperation with Colorado State University.*

Effects of Clearcutting a Subalpine Forest in Central Colorado on Wildlife Habitat

Glenn L. Crouch

Management Implications

Subalpine forests in the central Rocky Mountains are regarded as prime producers of water for downstream users. The accepted practice for enhancing water flow from conifer stands is clearcutting relatively small blocks in such a way that interception losses are modified, deposition of snow is increased in the clearcut blocks, and the melting regime is altered (Hibbert 1979, Troendle 1983).

Monitoring understory vegetation before and after clearcutting 12, well-distributed, 3-acre circular blocks comprising about 35% of a 100-acre watershed indicated that plant production generally increased on average sites, and made major gains on one moist site. Big game forage quality characteristics also improved after logging. Herbivore activity varied among the species.

This logging practice was considered to be beneficial for big game and other animal species requiring or favoring forest openings. Impacts were evaluated as neutral or only mildly negative for animals requiring or favoring closed-canopy or old-forest stands, such as cavity-nesters and snowshoe hare, because the openings were small, and relatively few. Removal of the intervening uncut timber probably would increase big game forage, but could be detrimental by decreasing cover availability. Closed-canopy dwellers also would be adversely affected by a large decrease in mature timber.

INTRODUCTION

Much of the informaton on water production from forests in the central Rocky Mountains has been developed at the USDA Forest Service's Fraser Experimental Forest, in Colorado. Research at the Experimental Forest dates from the 1930's, with the major experimental effort until recently, consisting of the Fool Creek watershed study. For this study, 278 acres of mature subalpine timber on 550 acres of commercial forest land were clearcut in alternate variable width strips, from 1954 through 1956, to increase streamflow from the watershed (Alexander and Watkins 1977).

Two years after logging on Fool Creek, more mule deer (*Odocoileus hemionus*) fecal groups were found on clearcut than on uncut strips, and production of some plant species was somewhat greater on the clearcut areas (Porter 1959). Fecal counts in 1966, about 10 years later, showed nearly three times more droppings per acre on clearcut strips than on adjacent uncut areas (Wallmo 1969).

Studies of deer feeding preferences and amounts and quality of forage available to them in the snow-free season were conducted in 1970 and 1975, 15 and 20 years after logging. Results showed that deer fecal counts and forage production were greater on clearcut than on uncut strips, but that inherent forage quality as indexed by crude protein content and digestibility was not different between the two treatments (Wallmo et al. 1972, Regelin et al. 1974, Regelin and Wallmo 1978).

The study reported here was conducted in a nearby watershed to describe the initial responses of selected herbivores and understory plant production to a different water enhancement cutting practice than was applied at Fool Creek.

STUDY AREA

The study was conducted on a south-facing segment of the 667-acre Deadhorse Creek Watershed on the Fraser Experimental Forest. Elevations average about 10,000 feet, and slopes range from gentle to greater than 70%. Soils are gravelly, sandy loams with low erodability (Retzer 1962). Winters are long, cold, and snowy, and summers are cool and moist. Annual temperatures averaged about 32°F, and precipitation 25.6 ± 3.7 inches at the on-site Deadhorse gauging station during the 7-year study period. About two-thirds of the annual precipitation falls as snow from October through May.[2]

The experiment on which this study was superimposed utilized a current "state-of-the-art" cutting practice for maximizing water production. It consisted of monitoring snow depths and water leaving the site before and after clearcutting 12, more or less evenly-spaced, 3-acre circular patches (r = 204 feet) in a 101-acre segment of the Deadhorse Watershed (Troendle 1983) (fig. 1).

Overstory vegetation consisted of mature to overmature Engelmann spruce (*Picea engelmannii*),[3] subalpine fir (*Abies lasiocarpa*), and lodgepole pine (*Pinus contorta*). A few large, old Douglas-fir (*Pseudotsuga menziesii*) also were present. Understory vegetation on most of the Watershed was low-growing, and dominated by *Vaccinium scoparium* with lesser amounts of *V. myrtillus*, a few other low shrubs, and very sparse scattering of sedges and forbs. This vegetation corresponds closely to the *Abies lasiocarpa/Vaccinium scoparium* plant association that has been widely de-

[2]*Data on file at the Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.*

[3]*Plant nomenclature generally corresponds with Harrington (1954).*

Figure 1.—Distribution of 3-acre circular clearcuts designed to augment streamflow on Deadhorse Creek in central Colorado.

scribed in the northern and central Rockies (Hoffman and Alexander 1976, 1980, 1983).

A small, more moist, and subsequently highly important part of the area was occupied by vegetation resembling that described as an *Abies lasiocarpa/Picea engelmannii/Senecio triangularis* plant association (Hess 1981). Although the stand was aged, it was more or less intact, with relatively little dead wood on the ground.

The Watershed serves as spring, summer, and fall habitat for mule deer and elk (*Cervus elaphus canadensis*) and various bird species, and as year-round habitat for many resident species, such as blue grouse (*Dendrogapus obscurus*), gray jays (*Perisoreus canadensis*), and mountain chickadees (*Parus gambeli*) (Scott et al. 1982) and pine marten (*Martes americana*), snowshoe hare (*Lepus americanus*), and golden mantled squirrels (*Spermophilus lateralis*) (Alexander and Watkins 1977).

Scott et al. (1978) described the snag component of the study area before logging, and the response of birds and small mammals to clearcutting shortly after logging (Scott et al. 1982).

METHODS

The area was logged in 1977. Merchantable material was transported to roads by rubber-tired skidders, except on the steepest slopes where crawler tractors were used. About 10,000 fbm/acre were hauled to the mill. During logging, all live trees greater than 4 inches d.b.h. were felled. Slash was scattered, and steeper skid-trails were seeded with grasses to control erosion. Species seeded included *Melilotus alba* and *M. officinalis*, *Agropyron intermedium*, and *Lolium perenne*, each at 15%, and *Bromus inermis*, *Agropyron trachycaulum*, *Phleum* sp., and *Poa pratensis*, each at 10% of the total mixture. Seeding rates were unknown; but, relatively little of the clearcut area was seeded.

For this study, four blocks judged to be typical of those to be clearcut were paired with four adjacent uncut sites. The four patches to be logged are subsequently referred to as "average" sites. In addition, a fifth block, on a much wetter site, and also scheduled for logging, was selected for study. However, there was no comparable uncut wet site to serve as a control.

Moist sites occur on small benches and are watered by springs or seeps, or occasionally by shallow drainages. Logging operations may greatly widen the drainage, or may increase the area influenced by the spring, and thereby create larger, well- or excessively-watered areas. Overstory removal upslope, or on the moist sites themselves, also may increase amounts of water available for understory plant growth.

Observations prior to the study indicated that sites available for controls within the study area had similar species composition, but greater amounts of understory vegetation than the blocks marked for clearcutting. Consequently, direct comparisions between responses

on clearcuts and controls were not appropriate. Therefore, comparisons were made separately within the clearcut and uncut components; and effects of logging on the attributes measured are inferred where annual and periodic changes occurred on clearcut but not on uncut blocks.

Inventories of the vegetative component and herbivore activity were conducted on the same grid. All data were collected on three parallel, 275-foot lines located about 100 feet apart, with the center line passing near each block center. Lines were oriented parallel to slopes and began and ended about 50 feet from block edges. Lines were permanently marked with wooden stakes at 55-foot intervals. Thus, a total of 15 staked points, 5 on each line, were established on each block. Except for overstory measurements and fecal counts, plot stakes were used only to orient sampling each year.

Prelogging stand characteristics were determined from 4-milacre circular plots centered at each wooden stake in each block. Within each plot, trees were counted by species, and their diameters (d.b.h.) were measured. Logging slash expressed as percent cover was estimated each year after logging, during understory plant inventories.

Plant Production and Ground Cover

Plant production was determined by clipping current growth to a 5-foot height, within ten, 1-foot quadrats spaced equally along each sampling line. Woody plants, graminoids, and forbs were sacked separately, were weighed green in the field, and later were oven-dried at 55°C to determine moisture content. In addition, samples of *Vaccinium* spp., *Carex rossii*, and *Arnica cordifolia*, the most common shrub, graminoid, and forb on uncut and clearcut blocks, were collected 3 and 5 years after logging to help to interpret forage quality data.

Plant cover by species was estimated by 10% increments in fifty, 1- by 2-inch rated microplots spaced about 5 feet apart on each line (Morris 1973). Logging slash was similarly inventoried during plant sampling.

Production and cover were measured near the peak of each growing season, during the second or third week of August each year from 1976, the year before logging, through 1982, the fifth year after logging was completed.

Effects of the clearcutting on the quality of understory vegetation as potential forage were evaluated after clearcutting by comparing moisture, crude protein content, and dry matter digestibility using analytic procedures similar to those used by Regelin et al. (1974). Rumen inoculum from a domestic cow, fed grass hay, was used in digestibility determinations.

Herbivore Activity

Elk, deer, and snowshoe hare activity was monitored in the fall each year from pellet group counts made on five, 8- x 55-foot segments on the two outside sampling lines in each block.

Data Analysis

Analysis of variance ($P = 0.05$) was used to test for annual and periodic differences for all measured attributes. Tukey's test was used to separate means where appropriate (Snedecor 1961). Linear regression ($P = 0.05$) was used to test for significance of time-trends after clearcutting. The quantitative statements greater or lesser, increases or decreases, etc., used in the following sections indicate that values reported are significantly different, or that time-trend relationships are significant ($P = 0.05$).

RESULTS

Prelogging overstory characteristics, including the contributions of each tree species to the total component, are shown in table 1. As expected, logging reduced numbers and basal areas of trees dramatically in the clearcut blocks. However, there was sufficient advanced regeneration remaining—more than 300 seedlings and saplings per acre—to adequately stock the clearcut blocks after logging. Tables 2, 3, and 4 show cover of slash before and after logging. Amounts within clearcut blocks ranged from none to heavy, depending on location, and averaged 20% cover during the 5-year post-logging period.

The small gain in slash on uncut blocks resulted from blowdown, probably triggered by clearcutting in the nearby logged sites. Skidding on the moist site caused somewhat boggy conditions over much of that block.

Plant Production

Average Sites

Before logging, the bulk of understory biomass was produced by the woody plant component on both the uncut blocks and those to be clearcut. The same pattern

Table 1.—Prelogging overstory characteristics on uncut and clearcut blocks in a subalpine forest in central Colorado.

	Engelmann spruce	Subalpine fir	Lodgepole pine	All species[1]
		Number per acre		
		≥4.0 inches d.b.h.		
Uncut	46	183	79	308 ± 71
Clearcuts				
Average	104	104	108	316 ± 73
Moist	117	100	17	234 ± 82
		Basal area (ft²/acre)		
Uncut	27.9	51.8	43.1	122.8 ± 38.5
Clearcuts				
Average	48.8	26.7	71.3	146.8 ± 41
Moist	102.9	32.2	2.7	137.8 ± 80.0

[1]*Confidence intervals* = $\bar{X} \pm t.05\,(S\bar{X})$.

Table 2.—Percent understory cover on uncut controls adjacent to average clearcut blocks in a subalpine forest in central Colorado.

Growth form and species	Before logging (1976)	Years after logging (1978-82)					Before versus after logging[1]	
		1	2	3	4	5		
Woody plants								
Vaccinium spp.	32.4	34.0	36.4	31.0	30.7	35.7	32.4a	33.6a
Pachystima myrsinites	3.6	3.8	2.9	4.8	3.9	3.6	3.6a	3.8a
Shepherdia canadensis	3.0	3.5	2.7	4.4	3.8	3.1	3.0a	3.5a
Juniperus communis	0.9	1.2	1.8	0.9	1.4	1.9	0.9a	1.4a
Abies lasiocarpa	0.8	1.0	1.0	0.5	0.5	1.0	0.8a	0.8a
Arctostaphylos uva-ursi	0.6	0.2	0.3	1.0	0.6	0.6	0.6a	0.5a
Rosa sp.	0.5	0.8	1.5	1.9	0.9	0.7	0.5a	1.2a
Pinus contorta	0.3	0.6	0.5	0.7	0.3	0.4	0.3a	0.5a
Berberis repens	0.2	0.4	0.2	0.4	0.5	0.6	0.2a	0.4a
All woody plants[2]	42.3a	45.5a	47.3a	45.6a	42.6a	47.6a	42.3a	45.7a
Graminoids								
Carex spp.	0.6	0.7	1.1	1.3	0.8	1.4	0.6a	1.1a
All graminoids[2]	0.7a	0.7a	1.1a	1.3a	0.8a	1.4a	0.7a	1.1a
Forbs								
Arnica cordifolia	4.3	3.3	4.2	4.8	3.3	4.8	4.3a	4.1a
Happlopapus parryi	0.7	0.8	1.7	1.3	0.8	1.1	0.7a	1.1a
Senecio crassulus	0.4	0.5	0.3	0.1	0.3	0.6	0.4a	0.4a
Cirsium sp.	0.2	0.1	0.4	1.3	0.6	0.9	0.2a	0.7a
Fragaria ovatum	0.2	0.1	0.6	0.3	0.3	0.4	0.2a	0.3a
Epilobium angustifolium	0.1	0.1	0.0	0.2	0.2	0.2	0.1a	0.1a
Geranium richardsonii	0.1	0.3	0.5	0.3	0.1	0.1	0.1a	0.3a
Pedicularis racemosa	0.1	0.1	0.3	0.4	0.7	0.5	0.1a	0.4a
Pyrola sp.	0.1	0.1	0.0	0.1	0.0	0.1	0.1a	0.1a
Others	1.0	1.0	0.7	0.6	0.5	0.7	1.0a	0.7a
All forbs[2]	7.2a	6.4a	8.7a	9.4a	6.8a	9.4a	7.2a	8.2a
Total plant cover[2]	50.2a	52.6a	57.1a	56.3a	50.2a	58.4a	50.2a	54.9a
Slash[2]	2.7a	3.0a	5.1a	6.6a	5.3a	5.7a	3.1a	5.1b

[1]*Within species, before and the mean value after clearcutting followed by the same letter are not significantly different ($P = 0.05$).*
[2]*Among years, means followed by the same letter are not significantly different ($P = 0.05$).*

Table 3.—Percent understory cover before and after clearcutting average blocks in a subalpine forest in central Colorado.

Growth form and species	Before logging (1976)	Years after logging (1978-82)					Before versus after logging[1]	
		1	2	3	4	5		
Woody plants								
Vaccinium spp.	17.2	12.6	18.3	18.8	14.7	22.4	17.2a	17.4a
Shepherdia canadensis	1.0	0.9	0.8	0.6	0.8	1.4	1.0a	0.9a
Pachystima myrsinites	0.7	1.7	3.0	2.8	3.4	3.4	0.7a	2.9b
Abies lasiocarpa	0.4	0.4	0.8	0.3	0.4	0.5	0.4a	0.5a
Arctostaphylos uva-ursi[3]	0.3	0.1	0.6	0.7	1.2	1.9	0.3a	0.9b
Rosa sp.[3]	0.3	0.3	1.6	2.3	2.2	2.8	0.3a	1.8b
Juniperus communis	0.2	0.2	0.8	1.4	0.8	0.6	0.2a	0.8a
Berberis repens	0.2	0.1	0.1	0.1	0.2	0.2	0.2a	0.1a
All woody plants[2]	20.3bc	16.3c	26.0b	27.0b	23.7bc	33.2a	20.3a	25.3b
Graminoids								
Carex spp.[3]	0.2	0.3	1.0	5.3	9.8	14.1	0.2a	6.1b
Seeded grasses[3,4]	0.0	0.1	0.5	0.8	1.9	2.3	0.0a	1.1b
All graminoids[2,4]	0.2c	0.4c	1.5c	6.1bc	11.7ab	16.4a	0.2a	7.2b
Forbs								
Arnica cordifolia[3]	0.3	1.4	3.1	4.0	4.6	5.0	0.3a	3.6b
Happlopapus parryi[3]	0.2	0.2	0.2	0.3	0.8	0.8	0.2a	0.5a
Senecio crassulus	0.1	0.2	0.2	<0.1	0.2	0.1	0.1a	0.1a
Epilobium angustifolium[3]	0.1	0.1	0.3	0.7	1.1	1.9	0.1a	0.8b
Cirsium sp.	0.0	0.0	0.0	0.0	0.1	0.4	0.0a	0.1a
Taraxacum officinale	0.0	0.0	0.3	0.2	0.9	1.0	0.0a	0.5b
Others	0.2	0.1	0.1	0.9	0.2	1.0	0.2a	0.5b
All forbs[3]	0.9c[2]	2.0c	4.2bc	6.1b	7.9ab	10.2a	0.9a	6.1b
All forms and species[3]	21.4d[2]	18.7d	31.7c	39.2bc	43.3b	59.8a	21.4a	38.5b
Slash[2]	2.0b	18.1a	20.2a	22.3a	20.8a	18.6a	2.0a	20.0b

[1]*Within species, before and the mean value after clearcutting followed by the same letter are not significantly different ($P = 0.05$).*
[2]*Among years, means followed by the same letter are not significantly different ($P = 0.05$).*
[3]*Cover is significantly correlated with years after logging ($P = 0.05$).*
[4]*From the erosion control seeding, only* Agropyron intermedium, Bromus inermis, *and* Phleum *spp. were encountered during plant inventories.*

Table 4.—Percent understory cover before and after clearcutting a moist site in a subalpine forest in central Colorado.[1]

Growth form and species	Before logging (1976)	Years after logging (1978-82)					Before versus after logging[2]	
		1	2	3	4	5		
Woody plants								
Vaccinium spp.	3.3	1.1	0.3	3.7	0.6	0.3	3.3a	1.2b
Rosa sp.	1.7	1.6	1.7	1.3	1.2	1.1	1.7a	1.4a
Ribes lacustre	1.3	1.0	2.3	2.0	1.0	2.2	1.3a	1.7a
Others[4]	1.5	1.6	1.3	0.5	0.0	0.0	1.5a	0.7b
All woody plants[3]	7.8a	5.3a	5.6a	7.5a	2.8a	3.6a	7.8a	5.0b
Graminoids								
Carex spp.	4.9	5.5	5.6	8.5	8.2	6.8	4.9a	6.9a
Bromus ciliatus	2.9	3.3	1.0	1.6	2.5	1.5	2.9a	2.0a
Calamagrostis canadensis[4]	0.2	0.3	4.2	4.1	4.2	10.9	0.2a	4.7b
Luzula parviflora[4]	0.1	0.2	0.0	0.8	2.9	6.7	0.1a	2.1b
Other native graminoids	0.0	0.7	0.0	0.0	0.0	0.0	0.0a	0.1a
Seeded grasses[4]	0.0	0.8	7.7	12.9	14.5	12.6	0.0a	9.7b
All graminoids[3,4]	8.1b	10.1b	18.5ab	27.9ab	32.3ab	38.5a	8.1a	25.5b
Forbs								
Geranium richardsonii	5.1	3.9	4.2	3.7	3.2	7.5	5.1a	4.5a
Arnica cordifolia	4.0	2.6	5.1	6.9	2.7	4.4	4.0a	4.3a
Pyrola sp.	2.7	0.8	5.7	3.9	1.4	2.3	2.7a	2.8a
Mertensia ciliata[4]	2.7	3.4	3.6	4.9	13.7	10.7	2.7a	7.3b
Smilacina stellata[4]	1.7	1.4	0.6	0.6	<.1	0.0	1.7a	0.5b
Senecio triangularis[4]	1.6	0.0	3.4	6.8	5.0	10.7	1.6a	5.2b
Erigeron sp.	1.1	1.1	0.9	0.0	2.3	2.7	1.1a	1.4a
Aconitum columbianum	0.9	3.4	3.2	3.5	3.1	5.7	0.9a	3.8b
Ligusticum porteri[4]	0.9	0.3	0.3	0.3	1.3	1.5	0.9a	0.7a
Equisetum arvense	0.7	6.7	21.5	18.1	17.0	30.9	2.0a	18.8b
Heracleum lanatum[4]	0.6	3.1	8.2	8.9	13.3	10.7	0.6a	8.8b
Cardamine cordifolia	0.6	0.7	0.7	4.4	4.3	6.1	0.6a	3.2b
Taraxacum officinale[4]	0.3	0.3	0.3	<0.1	0.5	0.4	0.3a	0.3a
Epilobium angustifolium	0.3	0.0	1.2	3.1	2.5	2.8	0.3a	1.9a
Others	7.6	0.0	1.9	0.0	7.6	7.0	3.6a	3.3a
All forbs[3,4]	30.8c	27.7c	60.8bc	65.1bc	77.9ab	103.4a	30.8a	66.9b
All forms and species[3,4]	46.7c	43.1c	84.9bc	100.5ab	113.0ab	145.5a	46.7a	97.4b
Slash[2]	3.0b	19.4a	18.6a	18.8a	17.6a	18.4a	3.0a	18.6b

[1]*No suitable mesic uncut block was available for comparison.*
[2]*Within species, before and the mean value after clearcutting followed by the same letter are not significantly different ($P = 0.05$).*
[3]*Among years, means followed by the same letter are not significantly different ($P = 0.05$).*
[4]*Cover is significantly correlated with years after logging ($P = 0.05$).*

persisted after logging although, as stated earlier, the uncut controls were more heavily vegetated than the areas to be logged (fig. 2). Table 5 shows that amounts of woody plants on the uncut blocks were similar through the study period, but that their production increased after logging on the clearcut sites.

Graminoids consisted of very small amounts of sedges on both uncut and clearcut blocks in the year prior to logging; a similar postlogging pattern persisted on the uncut controls. On clearcut blocks, graminoid production increased more or less consistently each year after logging, resulting primarily from greater amounts of sedges, but also from grasses seeded for erosion control (table 5).

Forb production was somewhat erratic from year-to-year on uncut blocks, but showed no overall change during the investigation (table 5). More forbs were produced on clearcuts after logging than before.

Among all growth forms, plant production was unchanged on uncut blocks, but increased markedly in the years after logging on the clearcut sites.

Moist Clearcut Site

Before logging, the moist site supported relatively few woody plants, but many species of graminoids and forbs. Plant production was also much greater before logging than on the average clearcuts (table 5). Woody plant production declined abruptly after logging and did not recover, whereas graminoids and forbs increased dramatically and consistently after clearcutting (fig. 3).

Ground Cover

Average Sites

Among all growth forms, plant cover was unchanged on uncut blocks, but increased after logging on those that were clearcut. Woody plants comprised the dominant growth form on all blocks before and after logging (tables 2 and 3). These plants made up 90% and 95%, respectively, of the understory cover on both clearcut

Figure 2.—Surface of an average clearcut block in the fourth year after logging on Deadhorse Creek in central Colorado. Plant cover, mostly shrubs, totalled about 43%.

Table 5.—Dry weight understory plant production (pounds/acre) on uncut and clearcut blocks in a subalpine forest in central Colorado.

Growth form and treatment	Before logging (1976)	Years after logging (1978-82)[1]					Before versus after logging[2]	
		1	2	3	4	5		
Woody plants								
Uncut	373a	484a	462a	392a	353a	416a	373a	421a
Clearcut								
Average	223b	242b	270b	314b	228b	447a	223a	300b
Moist	130a	32a	29a	46a	74a	14a	130a	39b
Graminoids								
Uncut	< 1a	1a	4a	7a	1a	1a	< 1a	3a
Clearcut								
Average[3,4]	1b	1b	9b	25b	98ab	136a	1a	54b
Moist[3,4]	137bc	46c	451bc	339bc	928ab	1,416a	137a	636b
Forbs								
Uncut	10a	15a	21a	22a	17a	33a	10a	22a
Clearcut								
Average[4]	1c	8bc	46b	45b	34bc	90a	1a	45b
Moist[4]	355b	106b	387b	1,254ab	1,181ab	1,865a	355a	959b
Totals								
Uncut	384a	500a	487a	421a	371a	450a	384a	446a
Clearcut								
Average[4]	225d	251cd	325bc	384b	360bc	673a	225a	399b
Moist[4]	622c	184c	867bc	1,639b	2,183b	3,295a	622a	1,634b

[1]*Within growth forms and treatments, means followed by the same letter are not significantly different (P = 0.05).*

[2]*Within growth forms and treatments, before and the mean value after clearcutting followed by the same letter are not significantly different (P = 0.05).*

[3]*Includes grasses seeded for erosion control.*

[4]*Production is significantly correlated with years after logging (P = 0.05).*

Figure 3.—Surface of the moist clearcut block in the fourth year after logging on Deadhorse Creek in central Colorado. Plant cover, mostly herbaceous species, totaled more than 100%.

and control blocks. Neither total woody cover nor cover of any of the species observed changed during the study on uncut blocks (table 2). Total woody cover and that of several individual species increased on clearcut blocks after logging.

Very small amounts of cover of two grass species and two sedges were found during the study on uncut blocks (tables 2 and 6). On clearcuts, however, cover of graminoids increased markedly after logging, with sedges and seeded grass comprising virtually all of the increase (table 3).

On uncut blocks, total cover of forbs and that of the common forb species were not different through the study period, whereas total forb cover, and that of four of the six species monitored, was greater after logging on the clearcut sites. *Arnica cordifolia* was the major increaser.

Logging had little effect on the presence or absence of individual plant species (table 6). Eleven woody species were found before and after logging on both clearcut and uncut blocks. Only four graminoids were documented during the study on uncut blocks. The same four species were present prior to logging on the clearcut sites; only one additional sedge, plus three grass species seeded for erosion control were listed after logging.

The same 10 forbs were present before clearcutting on all blocks (table 6). After logging, two additional forbs were found on both uncut and clearcut sites. Only one species, *Pedicularis racemosa*, was present before, and absent after logging on the clearcut blocks.

Moist Clearcut Site

A decline in the inherent low cover of woody plants followed clearcutting on the moist site (table 4). Herbaceous plants however, showed a three-fold gain in cover. Graminoids, especially *Calamagrostis canadensis*, and grasses seeded for erosion control were major contributors to the increase.

Forbs also showed marked increases in cover. Seven of the 15 forb species evaluated had greater cover after, than before logging. Largest gains were exhibited by *Mertensia ciliata*, *Senecio triangularis*, *Equisetum arvense*, *Heracleum lanatum*, and *Cardamine cordifolia*. All of these species are moist-site indicators in subalpine forests.

A total of 39 species was recorded before logging on the moist site (table 6). Four additional species were found after logging; three of these were grasses seeded for erosion control.

Table 6.—Plant species present (+) on uncut and before and after logging on clearcut blocks in a subalpine forest in central Colorado.

Growth form and species	Clearcut sites: Average Before	Clearcut sites: Average After	Clearcut sites: Moist Before	Clearcut sites: Moist After	Uncut sites: Before	Uncut sites: After
Woody plants						
Abies lasiocarpa	+	+	+	+	+	+
Arctostaphylos uva-ursi	+	+	+	+	+	+
Berberis repens	+	+			+	+
Juniperus communis	+	+			+	+
Lonicera involucrata			+	+		
Pachystima myrsinites	+	+	+	+	+	+
Pinus contorta	+	+			+	+
Picea engelmannii	+	+			+	+
Ribes lacustre	+	+	+	+	+	+
Rosa sp.	+	+	+	+	+	+
Shepherdia canadensis	+	+			+	+
Vaccinium spp.	+	+	+	+	+	+
Graminoids						
Agropyron intermedium[1]		+		+		
Bromus ciliatus	+	+	+	+	+	+
B. inermis[1]		+		+		
Calamagrostis canadensis			+	+		
Carex foena		+	+	+		
C. geyeri	+	+	+	+	+	+
C. rossii	+	+	+	+	+	+
Elymus glaucus			+	+		
Juncus balticus			+	+		
Luzula parviflora			+	+		
Melica bulbosa			+	+		
Phleum sp.[1]		+		+		
Poa pratensis	+	+	+	+	+	+
Forbs						
Aconitum columbianum			+	+		
Arnica cordifolia	+	+	+	+	+	+
Cardamine cordifolia			+	+		
Cirsium sp.		+	+	+		
Epilobium angustifolium	+	+		+	+	+
Equisetum arvense			+	+		
Erigeron sp.	+	+	+	+		
Fragaria ovalis	+	+	+	+	+	+
Geranium richardsonii	+	+	+	+	+	+
Haplopappus parryi	+	+			+	+
Heracleum lanatum			+	+		
Galium boreale			+	+		
Ligusticum porteri			+	+		
Mitella stauropetala			+	+		
Mertensia ciliata			+	+		
Osmorhiza obtusa			+	+		
Pedicularis racemosa	+				+	+
Pyrola sp.	+	+	+	+	+	+
Saxifraga arguta			+	+		
Senecio amplectens	+	+	+	+	+	+
S. crassulus	+	+	+	+	+	+
S. triangularis			+	+		
Smilacina stellata			+	+		
Solidago decumbens	+	+			+	+
Taraxacum officinale		+	+	+		
Veratrum californicum			+	+		

[1]*Grasses seeded for erosion control.*

Forage Quality

Average Sites

Moisture content of understory samples was unchanged over the postlogging period on the uncut blocks, averaging about 60% for the 5-year span (table 7). In vegetation from the clearcuts, moisture content gradually increased and was greater after 5 years, because the samples contained larger proportions of forbs which contained high amounts of moisture (tables 5 and 7).

Crude protein content was unchanged on uncut blocks, averaging 9.2% over the study period (table 7). On clearcuts, the understory contained less crude protein in the year after logging but was unchanged thereafter, averaging 10.4% annually.

Table 7.—Characteristics of understory vegetation on uncut and clearcut blocks in a subalpine forest in central Colorado.

Characteristics and treatments	Years after logging (1978-1982)[1] 1	2	3	4	5	5-year mean
Moisture (percent)						
Uncut	56.8b	59.3a	59.2a	59.0a	59.8a	58.8
Clearcut						
Average[2]	57.0b	58.0ab	59.7ab	60.5ab	62.3a	59.5
Moist[2]	62.3a	64.5a	74.4b	73.3b	76.3b	70.1
Crude protein (percent)						
Uncut	8.6a	9.2a	9.1a	9.1a	9.8a	9.2
Clearcut						
Average	8.2b	10.2ab	11.1a	11.4a	11.1a	10.4
Moist	10.8ab	8.2e	9.8bc	9.3cd	11.8a	10.0
In vitro digestibility (percent)						
Uncut	33.2bc	29.0c	32.5bc	35.7b	41.3a	34.3
Clearcut						
Average[2]	33.9c	33.0c	36.9bc	43.4b	51.3a	39.7
Moist	63.8a	64.9a	68.4a	65.1a	65.1a	65.5
Crude protein (pounds per acre, dry weight)						
Uncut	43a	44a	38a	33a	46a	41
Clearcut						
Average[2]	21b	34ab	43ab	41ab	68a	41
Moist[2]	20d	71cd	161bc	203b	389a	169

[1]*Within characteristics and treatments, means followed by the same letter are not significantly different ($P = 0.05$).*
[2]*Values are significantly correlated with years after logging ($P = 0.05$).*

Total amounts of crude protein available to herbivores are shown in table 7. These values were determined by multiplying annual understory production by its crude protein content. Amounts available on uncut blocks were similar over the postlogging period, averaging about 41 pounds/acre. Although crude protein availability increased after logging on the clearcuts, amounts available averaged only 41 pounds/acre, the same as on uncut blocks, because plant production was inherently lower than on the uncut sites.

In vitro digestibility of understory vegetation increased during the study on uncut and clearcut blocks, averaging 34% and 40%, respectively (table 7). The higher values on uncut sites were attributed to higher proportions of highly digestible forbs in the uncut understory and to more forbs, and equally highly digestible graminoids in the years after logging on the clearcut blocks (tables 5, 7, and 8).

Moist Clearcut Site

Moisture content of the understory vegetation increased after the moist site was clearcut (table 7). Gains in moisture content were attributed to steadily increasing proportions of native and seeded grasses, and forbs in the understory component (tables 4, 5, and 8).

Crude protein content was high in the year after logging, declined the following year, and then gradually increased again through the final 3 years (table 7). No reasons for this pattern were evident.

Crude protein availability increased dramatically during the years after clearcutting the moist site (table 7). Virtually all of the gains can be attributed to increases in total amounts of vegetation produced, rather than changes in proportions of the various growth forms in the samples.

In vitro digestibility was constant during the study, probably because relative amounts of highly digestible graminoids and forbs were already large by the first year after logging (tables 4, 5, and 7).

Herbivore Activity

Average Sites

Numbers of herbivore fecal groups were low before and after logging on both uncut and clearcut blocks (table 9). Also, there were no differences in numbers of elk groups before and after clearcutting on either set of blocks, although numbers increased gradually on the clearcut sites. Numbers of deer droppings, however, increased over the postlogging period on both areas, although numbers were still low. Hare activity, as indexed by frequency of plots occupied by fecal pellets, was lower after clearcutting but unchanged on uncut blocks.

Moist Clearcut Site

Elk and deer pellet groups were both more abundant after than before logging. Hare activity decreased after clearcutting (table 9).

Table 8.—Characteristics of three understory plants on uncut and clearcut blocks in a subalpine forest in central Colorado.[1]

	Years after logging (1978-82)					
	Vaccinium spp.		*Carex rossii*		*Arnica cordifolia*	
Characteristic	3	5	3	5	3	5
Moisture (percent)						
Uncut	57.3 ± 6.3	60.2 ± 1.5	54.3 ± 5.8	59.6 ± 5.6	80.0 ± 3.9	81.6 ± 4.2
Clearcut						
Average	60.3 ± 8.9	60.4 ± 2.5	58.9 ± 8.7	60.4 ± 2.6	77.7 ± 11.0	79.0 ± 3.1
Moist[2]	61.1	65.8	59.4	64.3	70.1	72.0
Crude protein (percent)						
Uncut	9.3 ± 1.0	11.0 ± 1.5	9.9 ± 3.7	10.4 ± 4.2	8.3 ± 2.0	9.4 ± 1.4
Clearcut						
Average	11.2 ± 1.9	12.6 ± 0.8	12.6 ± 2.2	10.9 ± 1.3	10.5 ± 1.0	11.1 ± 0.8
Moist[2]	11.8	12.6	13.9	12.5	12.6	13.5
In vitro digestibility (percent)						
Uncut	28.0 ± 3.4	31.1 ± 5.6	54.9 ± 6.0	62.7 ± 5.1	70.8 ± 5.8	77.5 ± 5.5
Clearcut						
Average	29.2 ± 3.2	38.3 ± 4.7	61.4 ± 1.6	61.3 ± 1.5	70.0 ± 5.4	72.1 ± 9.6
Moist[2]	27.1	32.9	62.2	62.1	68.4	65.4

[1]*Confidence intervals equal* $\bar{X} \pm t\ .05\ (S\bar{X})$.
[2]*Confidence intervals could not be calculated because values were obtained from single samples.*

Table 9.—Herbivore fecal groups on uncut and clearcut blocks in a subalpine forest in central Colorado.

Herbivore[1]	Before logging (1976)	Years after logging (1978-82) 1	2	3	4	5	Before versus after logging[2]	
	Number per acre							
Elk								
Uncut	23a	33a	18a	20a	28a	18a	23a	23a
Clearcut								
Average[3]	18ab	3a	0a	15a	28a	38b	18a	17a
Moist	30b	0b	110ab	70ab	90ab	120a	30a	78b
Deer								
Uncut[3]	13a	18ab	15ab	18ab	35ab	55b	13a	28b
Clearcut								
Average[3]	18a	5a	15a	40a	60ab	95b	18a	43b
Moist[3]	30c	10c	40bc	70abc	90ab	110a	30a	64b
	Frequency of occurrence in 0.1-acre plots							
Snowshoe hare								
Uncut	48a	60a	50a	35a	50a	50a	48a	49a
Clearcut								
Average	35a	8b	15b	3b	15b	38a	35a	16b
Moist	70a	70a	50a	0b	20b	0b	70a	28b

[1]*Within herbivores and treatments, means followed by the same letter are not significantly different (P = 0.05).*
[2]*Within herbivores and treatments, before and the mean value after clearcutting followed by the same letter are not significantly different (P = 0.05).*
[3]*Numbers or frequencies are significantly correlated with years after logging (P = 0.05).*

DISCUSSION

Logging on the clearcut blocks produced moderately large amounts of slash, which inhibited to some extent space availability for the growth of understory vegetation. In addition, many of the snags inventoried by Scott et al. (1978) were toppled by wind during the 5 years following logging, adding to the slash loading. Concentrations of slash also restricted accessibility to deer and elk on some parts of the clearcuts but probably had little effect on use by these animals. Studies in the western states and Canada have documented increases in understory production following partial or complete removal of tree overstories (Ffolliott and Clary 1982). Few, however, have concerned subalpine forests in the central Rockies, or long-term monitoring after clearcutting. Reynolds (1962) found that production peaked 6 years after logging ponderosa pine (*Pinus ponderosa*) in northern Arizona and declined to pretreatment levels after 15 years. Maximum understory development occurred at

11 years in clearcut and burned lodgepole pine in Montana (Basile 1975). Understory production (Wallmo et al. 1972) on Fool Creek 15 years after logging (853 pounds/acre) was still being sustained by the 20th year (759 pounds/acre) (Regelin and Wallmo 1978). Amounts of understory vegetation on comparable uncut sites were also similar (391 and 433 pounds/acre).

Production on average clearcuts had not reached these levels by the fifth year after logging, although an upward trend was evident at that time. Production on uncut blocks over the 5-year postlogging period was comparable to the 15- and 20-year levels on Fool Creek (table 5) (Regelin and Wallmo 1978). No data were obtained until 15 years after logging on Fool Creek; therefore, no estimates can be made as to the year(s) of peak production, or if production was declining at those times.

Whether plant production on the Deadhorse Creek clearcuts will continue to increase is uncertain. Cursory examination of data from 1983, the sixth year after logging, suggests that production that year, on average clearcuts, was about 40% lower than in the highly productive fifth year; but, this may be merely a result of good growing conditions one year, and poor conditions the next year.

Plant production and the variety of species before logging on the moist site far exceeded that on the uncut, or the average blocks. The same pattern was even more evident after clearcutting. The value of a moist environment in a subalpine forest ecosystem for production of potential big game forage was evident.

Virtually all plant species encountered were perennials. Woody plants were well represented in numbers of species and cover on the average clearcut and the uncut blocks. Graminoids and forbs, however, were relatively scarce on both areas, especially when compared with the moist site or Fool Creek (Wallmo et al. 1972).

Except for contributions from seeded grasses, increases in plant cover after clearcutting resulted almost exclusively from greater abundance of species present before logging, rather than from natural seeding from outside the study area. In fact, among all study sites, no native species was found after logging that had not been present before treatment. Similarly, no species present before logging was absent afterward (table 6).

Nearly all of the plant species observed are among those found to be eaten by deer on Fool Creek (Wallmo et al. 1972). According to studies elsewhere, many are also eaten by elk (Kufeld 1973, Thomas and Toweill 1982). Although *Vaccinium* spp. rated high in preference as deer forage on Fool Creek, its abundance was little affected by logging on the Deadhorse Creek area. Moreover, except for seeded grasses and the multispecies abundance on the moist site, there appeared to be little quantitative gain in availability of forage during the first 5 years after logging.

Changes in plant characteristics related to forage quality suggest that clearcutting was potentially beneficial. Moisture content, crude protein, and in vitro digestibility of understory vegetation increased through the study period on clearcuts, but was unchanged on uncut blocks.

Although widely distributed throughout the Fraser Experimental Forest during the spring, summer, and fall, elk and deer populations are small, as might be expected in this closed-canopy subalpine forest (Porter 1959, Wallmo 1969). No game trails were observed on the study area before or after logging. The relatively small acreage clearcut on Deadhorse Creek was not expected to radically change distribution patterns, or intensities of activity of these animals.

Although others, including Collins and Urness (1981) have demonstrated shortcomings of pellet group counts as indicators of elk and deer habitat usage, it is believed that they provide valid and useful information for the purposes reported here. Elk activity was unchanged on uncut and average clearcut sites before and after logging, but increased measurably on the moist site after clearcutting. Deer activity was greater after logging on uncut and all clearcut blocks.

The decline of snowshoe hare activity through 5 years after clearcutting was predictable, because these animals are known to favor more heavily vegetated habitats (Wolfe et al. 1982).

Effects of the logging on many other, small, nongame wildlife species appeared negligible (Scott et al. 1982).

CONCLUSIONS

Clearcutting in small blocks on a relatively dry site resulted in few major changes in understory vegetation and herbivore activity during 5 years after treatment. Logging a single moist site in this forest produced dramatic increases in plant production, species cover, and resulted in increased big game activity. Regelin and Wallmo (1978) showed that forage production was greater on clearcut than on uncut strips 20 years after logging on the nearby Fool Creek Watershed. Because trees grow slowly in central Colorado subalpine forests, the increases in forage availability observed over 5 years on the Deadhorse Creek blocks can be expected to persist at least as long as they have on Fool Creek.

Overall effects of this cutting pattern—the first entry into an extensive mature forest—on the wildlife species encountered and their habitats appeared negligible, except for the possible impact on species such as cavity-nesters, which require mature forest habitats. The potential for such adverse effects would be important only if prelogging habitats were fully occupied and no adjacent space was available for these species.

A second near-term entry into the same watershed potentially could have much more dramatic effects. Removing another 35% of the overstory by clearcutting would leave only about 30% of the area in mature forest, and might produce substantial on-site declines in wildlife species requiring such habitats, and increasing numbers of those favored by earlier successional stages. Big game forage would be increased; but, cover for them would be reduced. Closed-canopy dwellers also would be adversely affected as more mature timber is logged.

Similar changes, however, are likely whether the present forest is logged in any pattern, or regenerates naturally. The difference will be in the concentration of intensive activity required for logging compared with that occurring in the relatively imperceptible long-term natural succession.

However, the replacement of the old forest by catastrophic change, such as fire or insect infestation, could disrupt far more acreage in a short time than logging conducted in selective locations over long rotations.

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Crouch, Glenn L. 1985. Effects of clearcutting a subalpine forest in central Colorado on wildlife habitat. USDA Forest Service Research Paper RM-258, 12 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

Clearcutting 3-acre circular blocks on average and moist sites increased understory plant production and cover, but caused few changes in species composition. Plant moisture and crude protein content, and digestibility also increased after logging but, incidence of herbivore activity varied among species.

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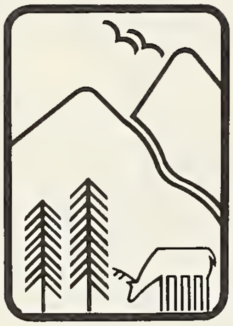
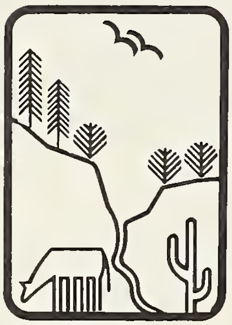


Rocky Mountains



Southwest

Great Plains

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